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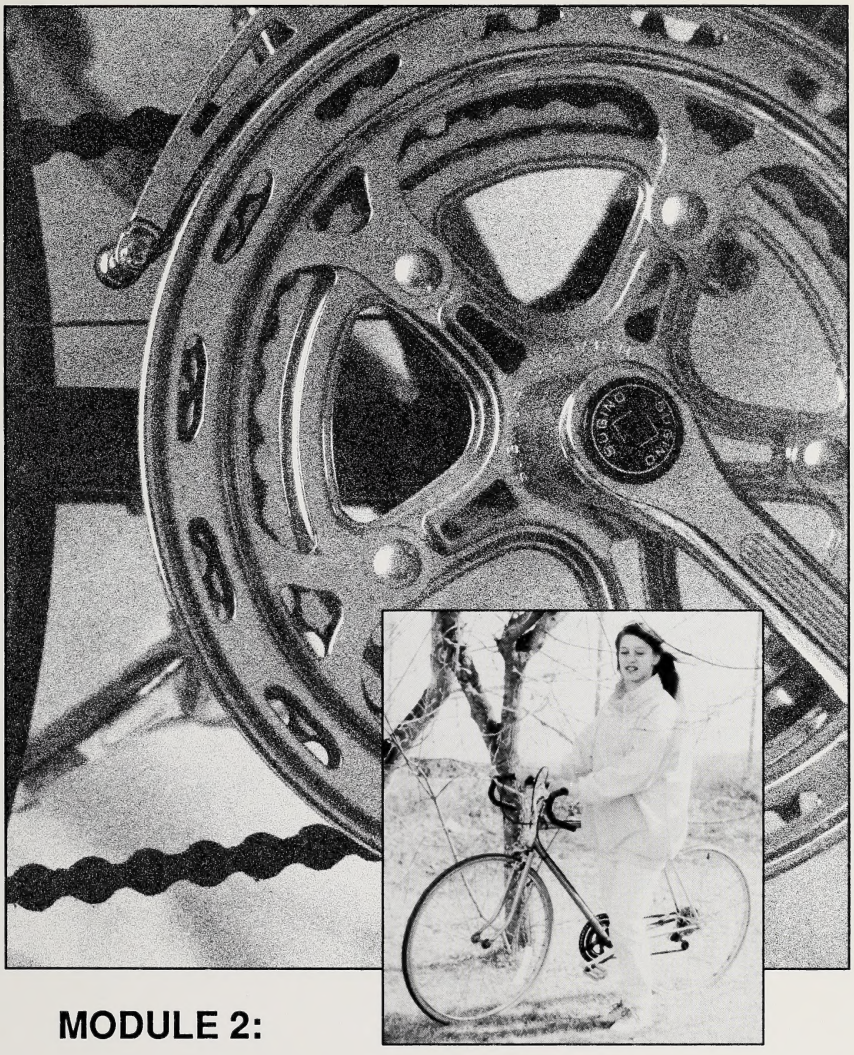

MODULE 2:

Energy and Machines

Distance Learning

Alberta EDUCATION

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Science 8

Module 2

ENERGY AND MACHINES

Distance Learning

Alberta EDUCATION

Science 8
Student Module
Module 2
Energy and Machines
Alberta Distance Learning Centre
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Welcome to Module 2!

We hope you'll enjoy your study of Energy and Machines.

To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

turn on your audiocassette and listen.

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OVERVIEW

Just think for a moment about all the machines you used from the time you got out of bed this morning. Did you open and close a door, turn a tap on and off, lift something off the floor, use a can opener, or take a bus somewhere? If you did, you were probably using a mechanical device, or in other words, a machine. Machines are very much a part of our daily living. They make our lives easier and more interesting.

In this module you will learn to identify both simple and more complex machines and their parts. You will have an opportunity to design and build your own machine to help you perform a specific task. Furthermore you will become aware of safety and efficiency in the designing and improving of machines.

Module 2
Energy and Machines

Section 1 **What Is a Machine?**	**Section 2** **How Are Machines Designed?**
Section 3 **How Can I Build a Machine?**	**Section 4** **Did Your Machine Stand the Test?**

Evaluation

Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete four section assignments. The assignment breakdown is as follows:

Section 1 Assignment	**24%**
Section 2 Assignment	**26%**
Section 3 Assignment	**20%**
Section 4 Assignment	**30%**
TOTAL	**100%**

Section

1

What Is a Machine?

Most of us tend to think of machines as very large, complex mechanical systems. You know, too, that not all machines are perfect – they break down. Have you ever experienced the frustration of fixing some device that is worn or broken? By studying how some simple machines work, you will have a better understanding of how larger, more complex systems work and how they save you time and effort.

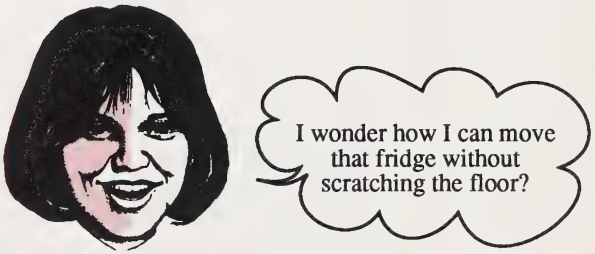
When you have finished this section, you will know the technical meaning of the word *machine* and be able to recognize simple machines. You will see how individual parts work together in a mechanical device, and you will appreciate the wide variety in the designs of machines.

Activity 1: Making Life Easy

Have you ever been by yourself with no one else around to help you move, lift, or carry an object?

Think of ways that you have tried to solve a situation like this in the past. Maybe you tried to move a piece of furniture, like a couch, down the hallway without damaging the wall. Did you construct a device of some sort to help you lift or carry the object? Did you think of a plan of action? Did you attempt a different way if your plan did not work? Were you concerned with safety for yourself at any point? When should you think about your safety? How many times did you try before you were able to move or lift the object? How did you feel when you finished the job?

At first you might have been frustrated or angry, but then you began to concentrate on how you could get the job done by yourself without damaging anything around you or causing injury to yourself. Different people have various ways of solving the problem. In fact some pretty funny things or dangerous situations can arise as the result of how people attempt to solve the problem or design a way to get the work done.

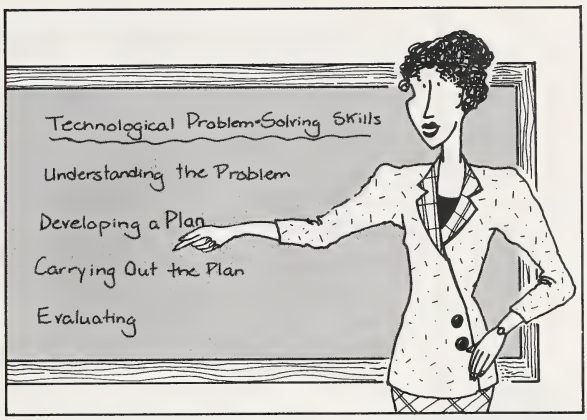


Read page 56 in your textbook, *Science Directions 8*. Several terms are defined as they are used in science. In the situation you were asked to think about you probably knew that it was going to take too much **energy** to move the object. Or maybe you could not apply enough **force** in order for **work** to be done.

You probably decided that you would need some device to help you push, pull, or lift the object. Many of these devices could be considered **simple machines**. You will learn more about these machines in the next activity.

8
Science Directions

Energy: *the ability to do work*
Work: *the result of the application of a force through a distance*
Machine: *any device that uses energy to perform a task*
Force: *a push or pull acting on an object*
Simple machine: *a machine made up of one or two parts used to perform a specific task or function*



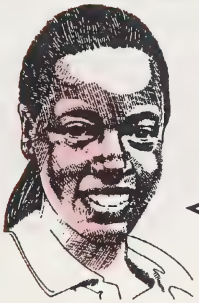
In applying science, technological problem-solving skills are often used. Think back to a situation in which you had to solve the problem of moving or lifting an object by yourself. Write a brief story describing the specific problem you tried to solve, what thoughts or plan you used, how you actually got the work done, and the conclusion you came to. If you cannot specifically recall a situation like that shown, be creative and make up a problem to solve, or think of someone you know who had a difficult situation to overcome.

When you write your story, show which parts of the story relate to understanding the problem, developing a plan, carrying out the plan, and evaluating the success of the plan.

1. Write your story on the lines that follow.

Check your answers with your learning facilitator.

Activity 2: Simple Machines



Machines are not always large objects powered by some kind of engine.

You're right! If you refer to your textbook or watch the film, you find out that something like a baseball bat is really a simple machine.

Do either Part A or Part B.

Part A involves watching a video and Part B involves reading from your textbook.

Part A

View the video *Simple Machines*. Watch for six types of simple machines. Do the questions that follow Part B.

Part B

If you did Part A, you do not need to do Part B.

Read pages 57 to 70 in *Science Directions 8*. You should be reading to find out the six types of simple machines.

Do the questions that follow.

End of Part B.

1. Using either the video or the reading, fill in the chart. For each simple machine give an example of a device that uses it. Sketch your example.

Type of Simple Machine	Example of a Device Using this Simple Machine	Sketch of Device

Check your answers with your learning facilitator.

2. For each device placed in the chart for question 1, describe its main use or function. For example, if there were a baseball bat in the previous chart, you would give its function as allowing the batter to hit a baseball into the field or over the fence.

Example of a Device Using a Simple Machine	Main Use or Function of Device

3. Illustrate the three types or classes of levers. Draw each type. Label the diagrams.

Refer to page 66 of your textbook to answer the next question.

4. If you have two wheels, a big wheel and a little wheel, working together as a wheel and axle, which one of the wheels is the axle?

_____

_____

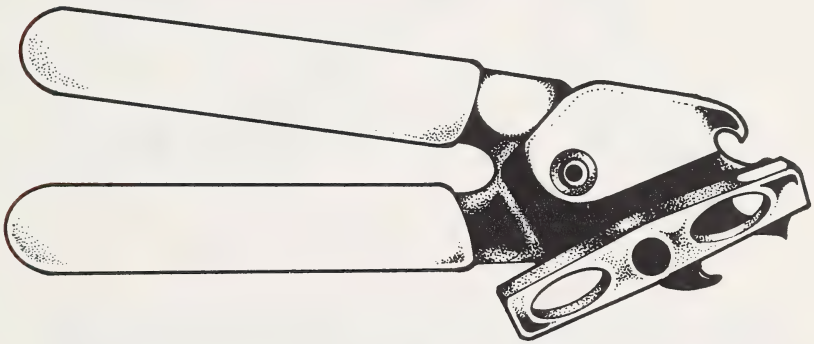
_____

Check your answers with your learning facilitator.

Before going on to Activity 3 make sure you can identify and describe the characteristics of each of the six simple machines.

Activity 3: The Part Becomes the Whole

Now that you can recognize some simple machines you will progress to some larger mechanical devices. As you studied and described some simple machines you probably began to realize that some of these simple machines are put together to operate as a larger machine that does some form of work for us. For example, if you take a close look at a can opener, you will find that it is made up of a wheel and axle as well as a lever and possibly even a wedge.



Now you are to identify the parts and the contribution each part makes within a larger system. You are to analyse two simple devices that you may find in your home, kitchen, or school. Some examples of devices you could work on are a stapler, benchvise, can opener, or pencil sharpener. Avoid electrical appliances. For each item you choose, find out (identify) what simple machines are found within the machine and what role or function each part plays. You may have to disassemble the device. Remember how this is done so that you can reassemble it. Check with a supervisor or facilitator before beginning.

In the next question you are to record your observations. You may do this in a tabulated form. This is shown for a pair of scissors.

Device	Simple Machines	Functions
scissors	levers	The levers are used to help your fingers place some force on the paper.
	wedge	The wedge helps force the paper apart.

For the two simple devices you worked on, tell what simple machines are involved and what function the simple machines have.

Check your answers with your learning facilitator.

Activity 4: Putting It All Together

Even though this activity is quite similar to Activity 3, there is a difference. Select one machine in your community – it can be in your kitchen, bedroom, school, or it may be something you have read about in a book or magazine. This machine is to be more **complex** than the devices you were exploring in Activity 3. It will contain more than one or two simple machines. In fact, when you look closely, you will see that it is composed of many systems or **subsystems**. For example, if you look at a lawn mower you will see a system for pushing or transporting, a system for doing the actual cutting of the lawn, and a system for starting the motor or generator.

Complex machine: a machine made up of several subsystems that perform one or more tasks

Subsystem: several simple machines working together to perform a specific task within a complex machine

1. In the space provided, draw or trace a picture of a more complex machine. Break the machine into its subsystems, label these systems, and describe the function of each system. (Hint: Remember when you were given a model, a toy, or a doll of some kind, and there was a diagram showing the parts and how to assemble it? Use the same idea.)

2. Provide a brief description of each term in the following space. The first one is done for you.

   a. part: a small piece used to make a simple machine

   b. simple machine: _____

   c. subsystem: _____

   d. complex machine: _____

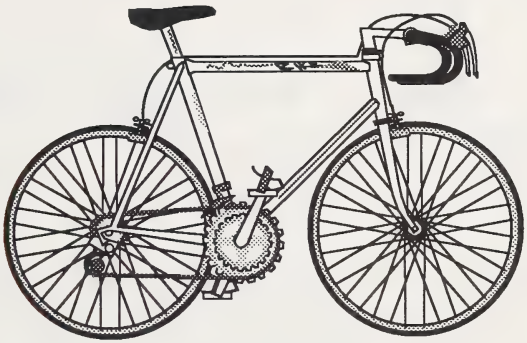
Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Machines are devices that use energy to help you do your work. Some of these machines are very simple devices such as the lever, inclined plane, pulley, wheel and axle, screw, and wedge. When you look at the larger machines around you, you usually can find some of these simple machines that work together to help the bigger machine do its job.



One example would be a bicycle. A bicycle is made up of many parts and subsystems which help the bicycle do its job of transporting or carrying you around.

1. Name three subsystems of a bicycle. Explain what each part does to help the whole bicycle work properly.

2. List three parts of a bicycle and describe which type of simple machine they represent.

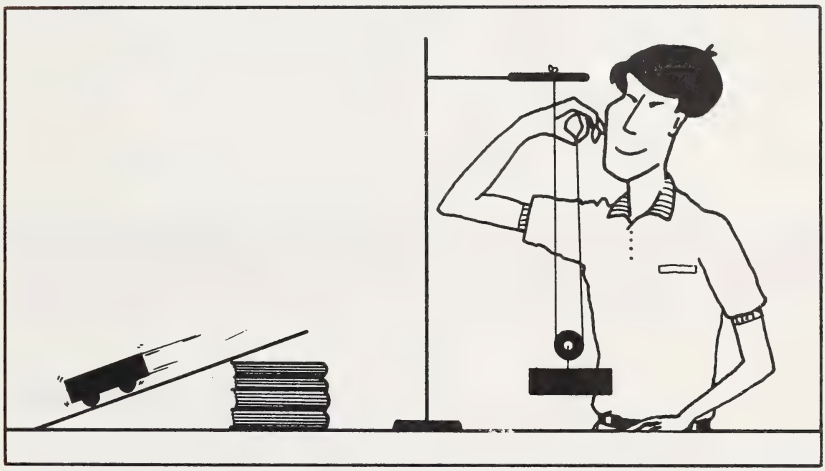
3. Make a list of ten machines.

4. What is the difference between a simple machine and a complex machine?

Check your answers with your learning facilitator.

Enrichment

In Section 1 you studied the various simple machines by observing the video or reading the textbook. As you looked at the characteristics of each simple machine did you think of ways you could build and test to see if the machine really did reduce the amount of effort or work needed?



Using Activity 2-1, Ramps and Pulleys, on page 58 in your textbook as a guideline, build a pulley system of your own. You will **not** need a spring scale to get specific measurements of forces even though in science we usually strive to get precise measurements. Naturally, if you do have a spring scale you can use it to compare forces. The purpose of this investigation is to compare the amount of effort needed when using a pulley or ramp with the amount of effort needed when not using a pulley or ramp. Without a scale you will be lifting the same load and the indicator will be yourself. How did it feel when you lifted or pushed while using the machine? How did it feel without the machine? Was it easier or harder?

You will need the following: a weight or load, such as a block of wood; string or thread; a smooth board; a single pulley (look for old spools of thread or old curtain/drape parts for wheels/pulley); a hook or clamp. You may ask your learning facilitator for help in obtaining these.

8 Science Directions

1. Draw or sketch one pulley or inclined plane system that you built. Label your diagram.

2. Compare the amount of effort you spent lifting the load directly, using your hand and arm, with lifting the same load using the pulley or the inclined plane.

_____

_____

_____

_____

_____

8 Science Directions

Using Activity 2-2, Experimenting with Levers, on page 61 in your textbook as a guideline, build or make the three classes of levers.

For the lever itself you can use a 30 cm ruler. You can use an eraser as a fulcrum. A small object can serve as the load. If you want to work on a larger scale you can use a two-by-four piece of lumber and a large brick.

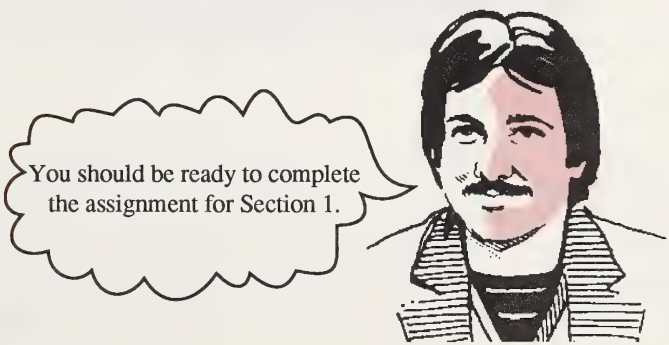
3. Sketch the three classes of levers you built. Label your diagrams. Draw an arrow to indicate in what direction the effort is applied.

4. Describe what happened to the effort required to lift the load with each type of lever. Did the effort change as you changed the type of lever?

Check your answers with your learning facilitator.

Conclusion

In this introductory section you have studied machines: what they are, what they do for us, and how they are put together. You should now understand that machines can be simple or complex, and that they help make our lives easier by performing work for us. You also should have developed an appreciation for the large variety of machines, and the fact that the same task may be performed by different machines in different ways.



ASSIGNMENT

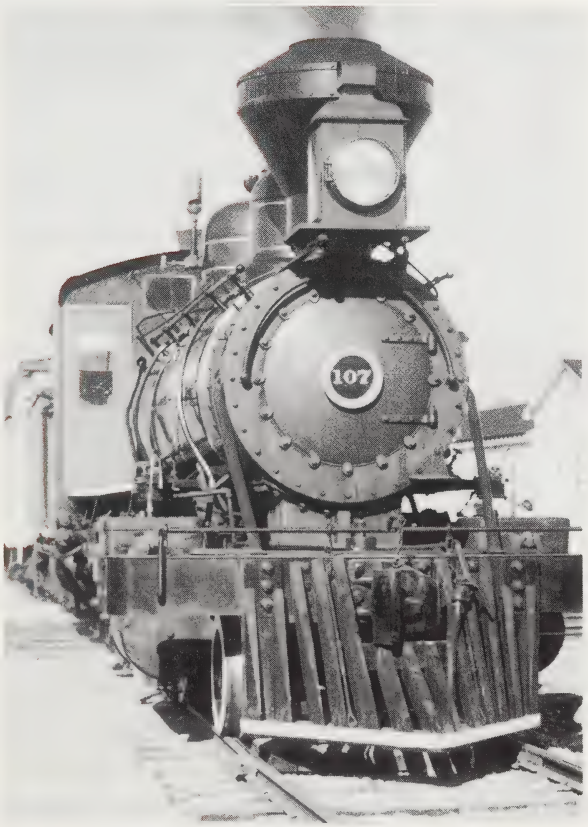
Turn to your Assignment Booklet and do the assignment for Section 1.

Assignment Booklet

Section

2

How Are Machines Designed?



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You know from Section 1 that larger machines are made up of of simple machines that may be combined together in systems and subsystems. Looking at the six simple machines as you did in Section 1 is only one way of studying how larger machines are put together. Look at the preceding picture of the old railroad steam engine. Are there other ways in which systems might link together? Remember some of the first toys you received as gifts – everything from wind-up dolls to spring-driven cars.

In this section you should be able to recognize ways in which systems and subsystems may be linked together. One very important way of linking is by using gears or gear systems. You will have an opportunity to analyse a gear system and to build or adapt one of your own.

Activity 1: Linking Machines Together

Have you ever watched a cheerleading team build a pyramid? Each person is linked to each other until the last person climbs up to form the top of the pyramid. Think of other instances that you have experienced or read about where linking gives either you or the whole group a decided advantage. Your examples could include everything from school work, sports events, and construction work, to energy and machines.

When travelling with a large group, such as a team, luggage can be removed from the bus by forming a human chain and passing the luggage along. The advantage of this kind of linking is that the luggage is removed faster and with less work for each team member.

1. List at least three examples of linking. For each example, give the advantage that the linking provides.

2. Recall your use of the words *work*, *energy*, and *force* in Section 1. Did any of your examples of linking machines in question 1 result in a change in the amount of work, energy, or force? Using one example that you can think of, or one that you already gave in question 1, describe what changes took place.

_____

_____

_____

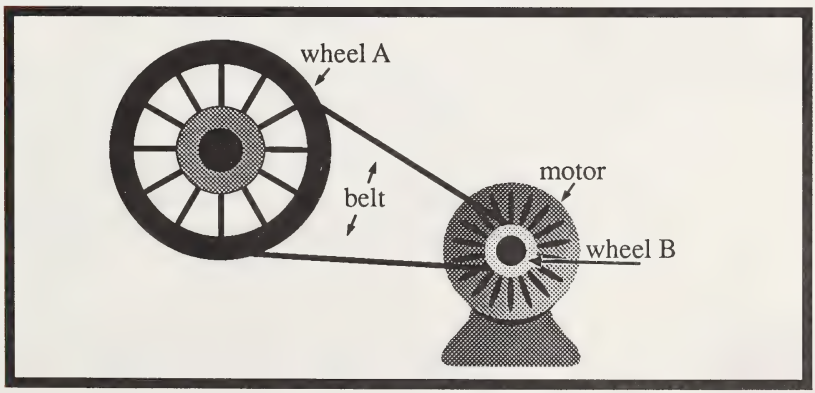
_____

_____

Check your answers with your learning facilitator.

Activity 2: Giving It the Gears

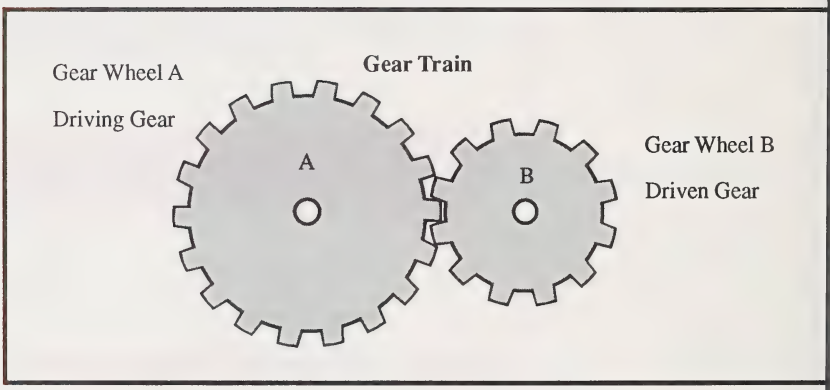
Many kinds of machines are operated by motors. Somehow the energy from the motor must be transferred to the machine itself. Think of ways this might be done. Some devices use belts to transfer the energy. See the picture which follows.



Can you think of other belt-driven devices or machines? Another method of transferring energy from the motor to the machine is by directly attaching the motor's shaft to the machine's shaft. Imagine the preceding picture with the shaft of wheel B being the same as the shaft of wheel A.

Gear: a wheel with teeth arranged around its edge used to transfer rotary motion and force from one machine to another

In many cases though, power is transmitted from one machine to another by gears instead of belts. **Gears**, much like the pulleys you studied in Section 1, are machines used for either gaining force or gaining speed. They consist of interlocking teeth meshed together. As you will find out, the way in which the gears are put together changes how the machine operates.



Gear train: two or more gear wheels which mesh together

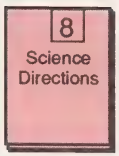
Driven gear: the gear wheel that is having the force applied to it

Driving gear: the gear wheel that is applying the force

Two or more gear wheels which mesh or which have their teeth interlocking are called a **gear train**. If only two gears exist, then the direction of rotation of one gear will be opposite to the other gear. Picture them turning. Gear B is smaller and is called the **driven gear** while Gear A is larger and is called the **driving gear**. Gear B will rotate, or turn, more rapidly than Gear A; therefore, this gear system would give you a gain in speed.

If the gears were the same size and had the same number of teeth, they would rotate at the same speed. If you have trouble visualizing this, try tracing the two gears shown on a piece of paper. Cut out the gears and stick a pin in the middle of each gear. The gears could be stuck to your notebook or to a bulletin board so that they mesh. Spin or rotate the gears using the pin as an axle. Observe which direction the gears are turning. What would happen if you meshed another gear between Gear A and Gear B?

Study pages 80-82 in your textbook and answer the questions which follow. Look for examples of different gear systems.



1. Draw and label a gear train (two gears) in which the driving gear and the driven gear rotate at the same speed.

2. Explain how multiplying gears and reducing gears work. Give examples of machines that use these types of gears.

3. Make a list of five machines that you know of that use gears or gear systems.

4. Could a gear system be used to change the direction of force? If the answer is yes, describe a machine that does this. (Hint: You might find one in your kitchen.)

_____

_____

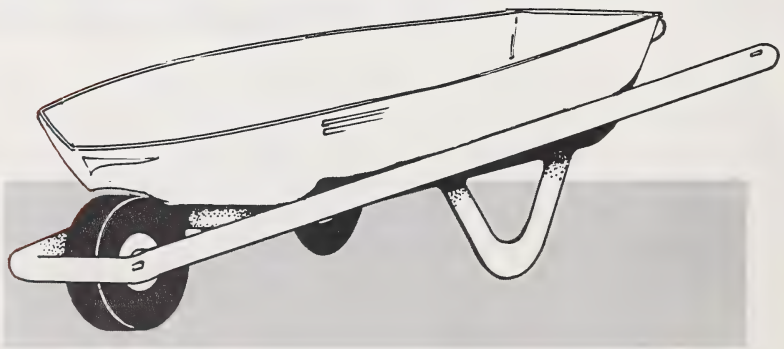
_____

Check your answers with your learning facilitator.

Activity 3: Building or Adapting a Gear System

The bicycle is one of the oldest machines that we still see daily on the streets of Canada. It is a part of a long line of transportation machines which undoubtedly began with the invention of the wheel. A transportation machine is, of course, any device that carries someone or something.

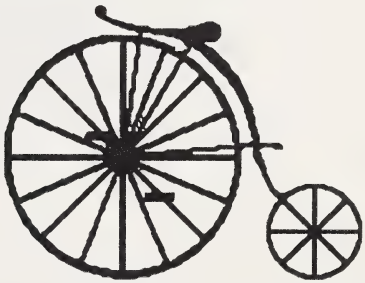
Before the invention of the bicycle the transportation machines were usually powered by a person or animal which was **not** on the machine. For example, think of the wheelbarrow – part of the wheelbarrow is supported by a wheel; the other part must actually be carried by a person. The person pushes and steers the wheelbarrow, but does not ride on it.



Even in the earliest bicycle, the load, the engine, and the control system was carried by the bicycle. The bicycle began as a frame with two wheels and a seat. The rider would straddle the seat, push off with his or her feet and coast as far as the bike would roll. None of these were called a *bicycle* yet. Every one of these machines was given (usually by the inventor) a better name than the last version had.

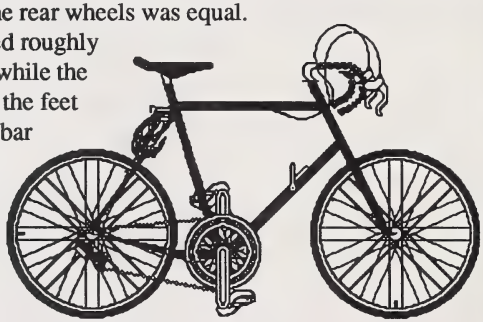
The first type of bicycle was followed by a number of different kinds of bicycles which were equipped with pedals. These pedals were at first direct extensions of the *hub*, the centre of the wheel. They were powered very much like a child's tricycle, without any chain. This could be called a *direct-drive* bicycle. A direct-drive bicycle is much harder to get going than a modern bicycle is. The British pennyfarthing, seen in the following picture, was probably one of the most difficult to get going.

Have you ever seen anyone riding one of these in a parade? Who provides the energy for this bike?



The pennyfarthing was named after two English coins: the penny, which was about the size of a Canadian dollar coin, and the farthing, which was about the size of a dime. This was a term of ridicule, and they were only called pennyfarthings after the development of the more familiar type of bicycle. Some of their front wheels were so large that several steps were needed to climb them. One French model had a wheel more than 3 m in diameter.

Out of many different-looking bicycles, the familiar-looking machine emerged. The diameter of the front and the rear wheels was equal. The height of the wheels reached roughly the middle of the rider's thigh, while the seat was high enough to just let the feet reach the ground. The steering bar still consisted of several shapes with slightly varying positions depending on what the bike was used for.



Most significantly, the pedal was separated from the hub of the wheel and a new mechanical subsystem was invented – the transmission. The energy was supplied by the rider to the pedal; from there it was transmitted by the chain to the rear wheel. The chain required the use of two special toothed wheels called **sprockets** to grab the chain between the teeth and move it. One of these sprockets was connected to the pedal, and the other to the hub of the rear wheel.

Sprocket: a gear wheel turned by a chain

I was just thinking.
In many heavily populated cities like Tokyo, Japan, Copenhagen, Denmark, Toronto, Canada, or even my own home town, automobile traffic has become such a nightmare that many people are switching to bicycles. While it may be in my own interest to use a bicycle for going to work or to school, it is also a means of reducing the amount of pollution produced by automobiles. Also, which is easier to park – a car or a bicycle?

Even though bicycles everywhere look pretty much the same, one of the biggest differences between bikes is how many speeds they have. There are some bikes that only have one speed. Beginner bikes and those old bikes with the curved handles are among them. Then there are three-speed and five-speed bikes. Racers will often have twelve-speed, fifteen-speed, and even twenty-speed bicycles. The most common, however, is the ten-speed bike. Since a ten-speed bicycle will probably be the easiest type to get a hold of, that is what the next discussion will deal with.

What do you mean when you talk about a ten-speed bike? Can you really only go at ten different speeds? Can you decide how fast you go or does the bike decide this for you?

To answer some of these questions, consider the idea of speed. Speed refers to how fast you move. If you could only pedal fast enough, you could go as fast on a one-speed bike as on a ten-speed bike. You would notice, however, that a person on a ten-speed bike is pedaling much slower to go the same speed. The secret to this lies in the extra sprockets. Remember sprockets are those toothed wheels that the chain runs on. Two sprockets are connected to your pedal and five are connected to the hub of the wheel. How do you get ten speeds out of seven sprockets?

As we saw before, the sprockets, no matter how many, and the chain are called a transmission. Another thing that is apparent right away is that all the sprockets are of a different size. When you change speeds you will notice that you are moving the chain from one sprocket to the next. Every combination of either front sprocket with any of the rear sprockets is called a gear, and that is what we will call the speeds from now on – gears. The first five gears are the combinations of one front sprocket with the five rear sprockets. The second set of five gears is the combinations of the other front sprocket with the five rear sprockets. Together that makes ten gears, or $2 \times 5 = 10$. Yes, the number of gears for any transmission like this can be calculated as follows:

number of front sprockets $\times$ number of rear sprockets = number of gears

8 Science Directions

Read Gears in a Bicycle on pages 83-84 of *Science Directions 8*.

1. Calculate the number of gears in bicycles with various numbers of front and rear sprockets.

   Enter your calculations in the chart.

Number of Front Sprockets	Number of Rear Sprockets	Number of Gears
1	5	_____
2	5	_____
2	3	_____
2	6	_____
3	4	_____
3	6	_____
3	5	_____
4	5	_____

2. Describe several observations about the gear system on a ten-speed bicycle.

_____

_____

_____

_____

_____

_____

Discuss your answers with your learning facilitator.

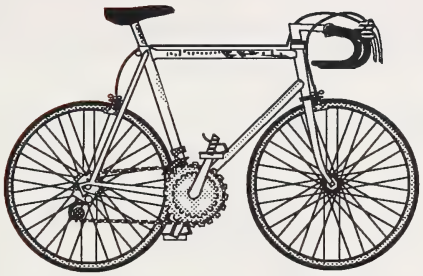
Activity 4: Evaluating a Gear System

In Activity 4 you will be applying what you learned about gears and gear systems to what actually happens when riding your bicycle on the road.

Do either Part A or Part B.

Part A requires the use of a ten-speed bike. Do Part B only if you are unable to use a ten-speed bike.

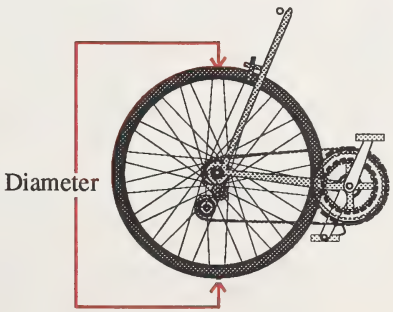
Part A



The purpose of this activity is to find out how far the wheel turns for one complete turn of the pedal in every gear.

You need a ten-speed bike and correction fluid, or some other marker. A calculator would help you do the calculations.

Find the circumference of the rear wheel. Do this by measuring the diameter of the wheel. Then multiply the diameter by 3.14. For example, if the diameter of a wheel is 70 cm, then its circumference is 70 cm $\times$ 3.14 = 220 cm.



1. What is the circumference of your bike's wheel? Show how you calculated your answer.

Turn your bike upside down so that it rests on the handle bars.

2. Complete the chart according to the directions that follow.

Front Sprocket	No. of Teeth	Rear Sprocket	No. of Teeth	No. of Turns of Rear Wheel for One Turn of Pedal	Distance Travelled for One Turn of Pedal
Example	50	Example	30	$\frac{50}{30} = 1.7$	$1.7 \times 220 \text{ cm} = 374 \text{ cm}$
A		A			
A		B			
A		C			
A		D			
A		E			
B		A			
B		B			
B		C			
B		D			
B		E			

In the preceding chart, A is used to refer to the smallest sprocket, B is used to refer to the next-to-smallest sprocket, and so on. For the example row the diameter of the wheel is 70 cm, and therefore, the circumference is 220 cm.

It is time to take a count. Count the number of teeth on the front and back sprockets of your bicycle. For your ten-speed, you will have to count the number of teeth for the two front sprockets (A and B) and the five back sprockets (A, B, C, D, and E).

To help you count the number of teeth use a marker, like correction fluid, to mark one tooth. Then count all the teeth on the wheel until you return to the mark.

Repeat the process for all sprockets or gears. Record these numbers in your chart.

On your bike you will observe that the rear sprocket will always turn more times than the front sprocket. This is called a step-up transmission. The way to calculate the number of turns of the rear wheel for each turn of your pedals is to use this ratio:

$$\text{Ratio} = \frac{\text{number of teeth in front sprocket}}{\text{number of teeth in rear sprocket}}$$

For the example shown on the chart the ratio is as follows:

$$\text{Ratio} = \frac{\text{50 teeth (drive gear)}}{\text{30 teeth (driven gear)}} = 1.7$$

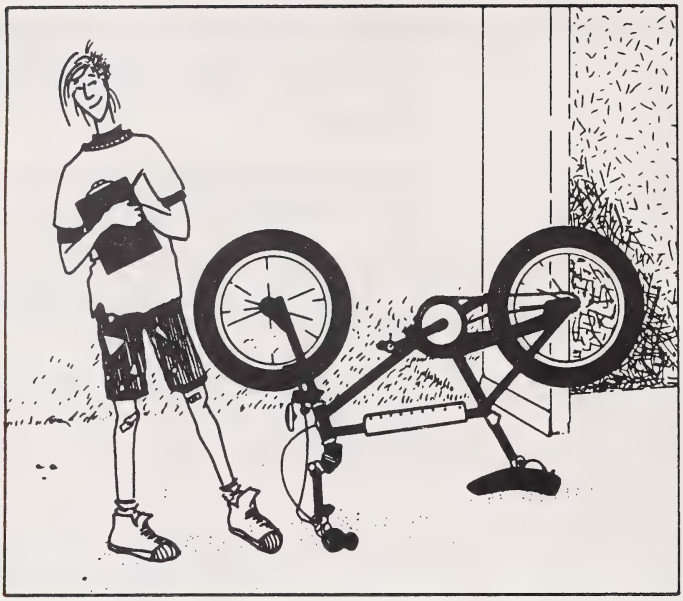
This means that the rear wheel gear turns 1.7 times for every time you make one complete turn of the pedals (front gear).

For every combination of front and rear sprockets calculate this ratio and enter it on the chart.

Finally, to complete the chart, calculate the distance your bicycle travels every time you make one complete turn of the pedals. To calculate this, multiply the gear ratio by the circumference of the rear wheel. For the example shown on the chart, the distance is $1.7 \times 3.14 \times 70$ cm = 374 cm or 3.74 m. This means that the bicycle travels 3.74 metres for every complete turn of the pedals.

Now that the chart is complete, look at the data inside the chart. Look for patterns that develop.

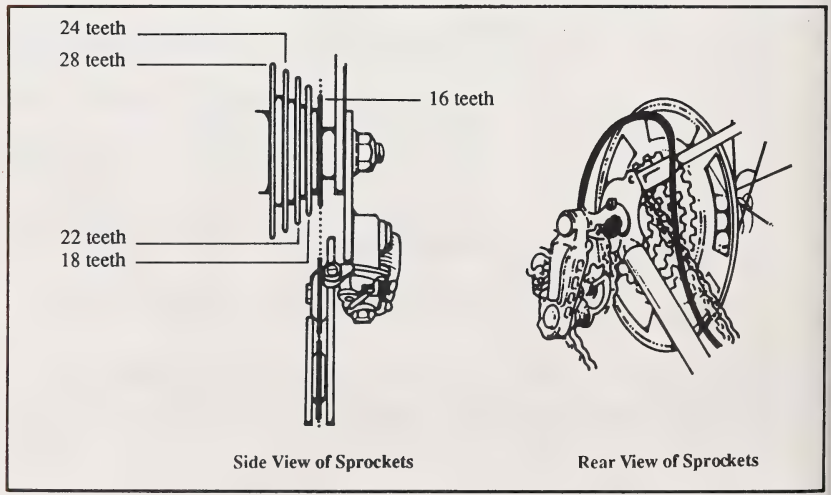
Continue with the question that follows Part B.



Part B

Do Part B if you were not able to use a bicycle. You will still follow the directions in Part A but the data is provided for you in Part B.

Suppose that your bicycle has a rear wheel diameter of 70 cm. This bicycle has two front sprockets. The larger front sprocket has 48 teeth and the other has 40 teeth. Furthermore, suppose that your bike has five rear sprockets, as shown in the diagrams. The sprockets contain 28, 24, 22, 18, and 16 teeth from the largest to the smallest sprocket.



3. Using the information given about your bicycle and using the directions in Part A as a guide, complete the table.

Front Sprocket	No. of Teeth	Rear Sprocket	No. of Teeth	No. of Turns of Rear Wheel for One Turn of Pedal	Distance Travelled for One Turn of Pedal
Example	50	Example	30	$\frac{50}{30} = 1.7$	$1.7 \times 220 \text{ cm} = 374 \text{ cm}$
A		A			
A		B			
A		C			
A		D			
A		E			
B		A			
B		B			
B		C			
B		D			
B		E			

In the previous chart, A is used to refer to the smallest sprocket, B is used to refer to the next-to-smallest sprocket, and so on. For the example row the diameter of the wheel is 70 cm, and therefore, the circumference is 220 cm.
Continue with the questions that follow.

End of Part B.

Using the technological problem-solving model outlined at the beginning of this module, write notes identifying the problem and describe what you did to solve the problem. Try this on your own first. Then use the following space to write your notes.

4. **Understanding the Problem:** What was the problem you had to solve in Activity 4?

5. **Developing a Plan:** What plan did you use to solve the problem? In your own words describe the method you followed. It will be similar to the directions you were given.

6. **Carrying Out the Plan:** What happened? Did you determine how far the wheel turns for one complete turn of the pedal in every gear? How did you use the marker? What happens as you gear up? gear down?

7. **Evaluating:** Did your plan, or method, successfully solve the problem? Did you have to alter your method?

_____

_____

_____

8. If you were riding your bicycle up a steep hill, what combination of front sprocket and back sprocket would you use? Explain why.

_____

_____

_____

9. If you were riding your bicycle on a level, smooth road and you wanted to go fast, what combination of front and back sprocket would you use? Explain why.

_____

_____

_____

_____

10. When touring, it is to your advantage to keep a constant rhythm or, in other words, to pedal at the same pace. What factors would require you to gear up or gear down?

_____

_____

_____

_____

11. If you were travelling against a strong wind, which gear combination would be easier to use? Choose I or II.

_____

Gear Combination	# of Teeth on Front Sprocket	# of Teeth on Back Sprocket
I	48	18
II	48	16

12. If you were on level ground, there was no wind, and you wanted the gear combination that would give you more speed at the expense of having to push harder on the pedals, which one would you choose? Choose I or II.

_____

Gear Combination	# of Teeth on Front Sprocket	# of Teeth on Back Sprocket
I	48	14
II	40	16

13. Your bicycle is a machine. If you use the bicycle frequently, what kind of maintenance would be necessary to keep the bike running well? (Hint: Think about friction, which occurs when parts rub against each other.)

_____

_____

_____

_____

_____

_____

_____

_____

Discuss your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

As you have seen, most machines require some form of energy to make them work. Sometimes this energy may be transferred directly, but quite often belts, pulleys, or gears are used to transfer the energy to the machine.

If you can find an old toy or kitchen device that uses gears, carefully turn a shaft and observe how the gears are linked or meshed together. If you cannot find a machine that uses gears, refer to a reference book with a picture of gears or refer to page 82 of your textbook.

1. Describe the gears. How many gears are linked together? How many teeth are on each one? Is one wheel larger than the other?

_____

_____

_____

_____

_____

2. Draw a rough sketch of the gears, and indicate on your diagram (by using arrows) the direction each gear is turning.

3. Give an example of a machine that uses reducing gears. Explain why reduction gears are needed and how they work.

Discuss your answers with your learning facilitator.

Enrichment

It has been said that the wheel and axle was one of the most important inventions in the history of the world. The gear has also contributed much to the development of human civilization. Gears have changed greatly in terms of the material they are made of, the jobs they perform, and the way they actually work.

1. Write a poem or story about gears. You may want to include the idea of how the gear was first used in early times compared to how gears are used today. Your poem or story might include the words *wheel*, *energy*, *link*, *effort*, *friction*, *teeth*, and *mesh*.

2. Sometimes gears break and get worn down because of friction. Suggest ways in which people have attempted to solve this problem.

_____

_____

_____

_____

Share your answers with your learning facilitator.

Conclusion

In this section you studied the importance of linking machines together. Belts, pulleys, and gears help to transfer energy from one machine to another. One machine most people are familiar with is the bicycle. The gear system on a bicycle can be observed fairly easily but you should realize that gear systems exist in many machines around us.

Gears, as well as machines, usually give at least three advantages. They can change the amount of force needed, the speed of the force, and the direction of force.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3

How Can I Build a Machine?

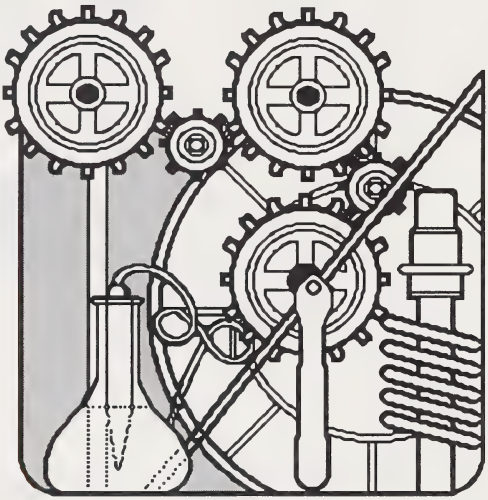
In the previous two sections you learned about simple machines and how they may be linked together to make a more complex machine. You will now get a chance to put this knowledge to work for you. Using the technological problem-solving model you will build a machine of your own. At first this may sound like a huge task, but when you were a young child you probably made your first machine with toy blocks or building sets. You probably are tinkering with or improving the machines around you on a daily basis. For example, if your curling iron or toothbrush holder breaks you will likely find a way of fixing them.

Some of you may have at one time entered a science fair project in which you built a device. You should be able to use much of your own experience when you build your machine.

In this section you will learn to construct a device or machine that uses the simple machines you already know about. You will also have an opportunity to evaluate your machine's safe operation and efficient use of energy.

Activity 1: Understanding the Problem

Have you ever watched a perpetual motion machine? You often see that kind of machine as a display in a shopping mall or a science museum. A ball starts rolling and drops into a tray; the sinking tray then triggers or brushes against another device, which in turn activates another device, and so on. The first ball causes a chain reaction which keeps the whole thing continually in motion. How many machines might be involved? Who knows, but it keeps some people amused for hours.



You will not have to build anything as complicated as a perpetual motion machine, but you will be linking three or more simple machines together to make a device that can perform a simple task or job for you. You can even give your machine a fancy name, but remember to plan ahead and to clearly identify the purpose of your machine.

Read Activity 2-4 on page 72 of *Science Directions 8*. You will be doing something similar to this activity.

8 Science Directions

Your problem is to design and build a machine of your own to carry out a specific job or task. Several simple functions that your machine could do are opening and closing something or lifting something.

1. List several simple functions that you might want your machine to do.

_____

_____

_____

_____

_____

_____

Purpose: the function or use for which a thing is made

By stating the task of a machine, you are telling what the **purpose** of the machine is. In this way you describe the problem.

2. Pick just one of the ideas you thought of for question 1. List the one task you want your machine to perform. Remember to keep it simple.

_____

_____

_____

_____

Specification: a rule or requirement for building and using your machine

Now that you have a simple job for your machine to do, pretend the machine that you are going to build will be in competition with other machines that are doing the same job. What rules or **specifications** do you want to follow? For example, if you are moving an object, how far does it have to move? What materials will you use? Is there a time limit you will set for yourself? Is there a maximum weight your machine must be able to carry?

3. Write your specifications in the space provided. Be brief.

Discuss your answers with your learning facilitator.

Activity 2: Developing a Plan

Recall your story in Section 1 where you had to lift or move an object by yourself without any damage or injury to yourself or your surroundings. Did you have a plan? What were the advantages of thinking and planning ahead before you started moving? In this activity you will be making a plan to solve the problem or task you outlined in Activity 1.

Make a list of materials that you will need to make your machine. The machine should be made up of at least three simple machines. Materials that you might find in your home are tools, fastening devices, nails, clamps, screws, glue, cardboard, paper, elastics, straws, ice cream sticks, wheels, thread, strings, pins, balls, spools, old bicycle parts, old boards, toothpicks, yourself (to operate a handcrank), batteries, old motors, and toy steam engines.

Another source of materials would be construction kits such as those mentioned on page 71 of *Science Directions 8*. See your facilitator about help if you cannot obtain the materials you need or if you are not sure about a safety factor.

1. List the materials for your machine.

_____

_____

_____

_____

_____

2. In the space provided, describe your plan for solving the problem. Indicate in your answer how you are building your machine; use a diagram or a sketch. Have you considered more than one way of building your machine? Did you get your idea entirely on your own or from other sources? What type of power or source of energy will you need?

Note: Have your facilitator check over your plan before going any further.

Discuss your answers with your learning facilitator.

Start building your machine once your facilitator gives you the go-ahead. If you get stuck, you may take a break and start the next activity.

Activity 3: Carrying Out the Plan

Have you ever had to put together a kit or model, or maybe a piece of furniture that comes in pieces? You are usually given a set of instructions, a diagram of the numbered parts, and a set of steps for putting the parts together. What happens if the parts are not all there? What happens if you do not follow the exact order of the instructions? What if the instructions are not clear? Of course the potential for these things to happen is always there. Most adults, and probably most teenagers, could describe at least one frustrating experience they had with a set of instructions. They might have to reread and redo the steps or make changes to the design if they had already built parts. The word you will use to describe this is **troubleshooting**.

Troubleshooting: making changes to the original design of a machine

You may have reached the heights of frustration while building your machine. One advantage you have at this point is that you can leave the project alone – "take a breather" – and then come back to it.

1. Describe any difficulties you had when you were building your machine.

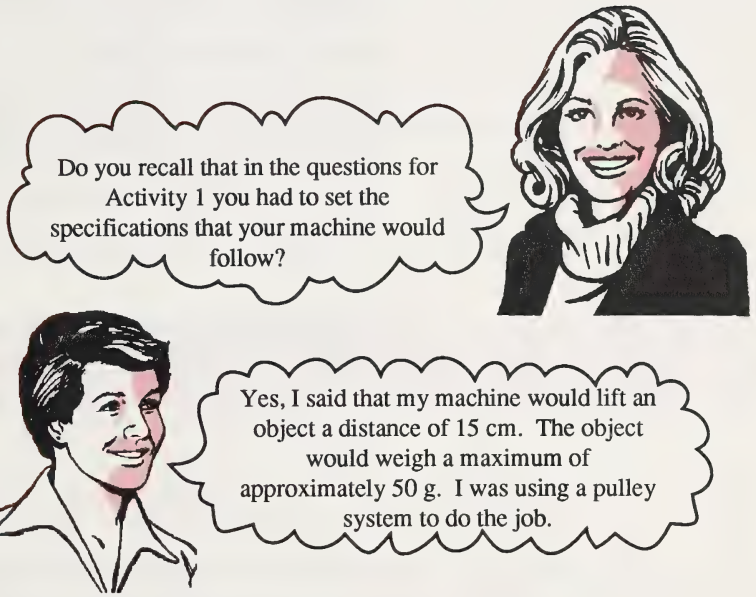
Discuss your answers with your learning facilitator.

2. Describe any changes you made in your plan after you started to build.

3. At what point did you decide that you had completed the building of your machine? Hint: Think back to the problem you had to solve and the specifications you had to meet.

Discuss your answers with your learning facilitator.

Activity 4: Evaluating Your Design


Do you recall that in the questions for Activity 1 you had to set the specifications that your machine would follow?
Yes, I said that my machine would lift an object a distance of 15 cm. The object would weigh a maximum of approximately 50 g. I was using a pulley system to do the job.

When you set the requirements for your machine in Activity 1, you were asked to pretend that your machine was in competition with other machines. Now it is time to find out if your machine met those standards. To help you find out or, in other words, to evaluate your design, answer the questions which follow.

1. Did your machine work? Were you satisfied that it met your specifications? Why or why not?

2. Could you identify problems with excessive friction or with the fit of moving or meshed parts? If the answer is *yes*, describe the problems.

3. What changes did you make or would you make next time if you could rebuild your machine?

There are many energy sources that could have been used to power your machine. Some of these are

- human (chemical)
- electric motor
- light or solar
- heat (also called thermal energy)
- engine using gasoline or some other fuel
- spring or elastic

4. What form of energy did you use to power your machine?

Alternative: a choice between two or more things

5. Can you think of **alternatives** or different forms of energy that you could have used to power your machine?

_____

_____

6. What safety factors did you have to consider when building your machine?

_____

_____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Building a machine yourself can be fun and productive, but sometimes frustrating as well.

To get an idea of how a machine can be built to perform a common task, go through your kitchen and make a list of several items that perform a simple task. For example, a pizza cutter cuts pizza.

1. List two items used in the kitchen to perform simple tasks.

_____

_____

Pizza Cutter

WESTFILE

2. Using the the pizza cutter as an example, choose one of the items you listed and make a sketch of it. Label the simple machines involved.

The pizza cutter could be made differently. Carve the handle out of a tree branch. Cut a slot in the handle to fit the wheel. Drill a hole through the handle at one end – the end of the slot. Trace a circle in a piece of sheet metal. To make the cutter, cut out the circle and drill a hole in the middle of the metal disk. Attach the cutter to the handle by pushing a bolt through the holes in the handle and through the hole in the cutter. Secure with a nut.

3. Using the machine you picked to answer question 2, think of how you could build the same machine using different materials.

4. Could you think of ways in which your design was better than the original device? Could you think of ways in which yours is not as good?

Discuss your answers with your learning facilitator.

Enrichment

In this section you learned to build a machine that met specifications that you set out for yourself. To help you build the machine, you followed the technological problem-solving steps: understanding the problem, making a plan, carrying out a plan, and evaluating the plan. Look through magazines, newspapers, or encyclopedias for scientists who made a major invention of a machine of any type. Take time to read about the invention and how the machine has contributed to humankind. References may include magazines such as *Scientific American*, *Science Digest*, and *Omni* and newspapers such as *The Calgary Herald*, *Edmonton Journal*, and *The Edmonton Sun*. Sometimes newspapers refer to inventions in their science sections which are usually printed once a week.

1. What type of machine was invented and who built the machine?

2. Do you think all inventors use basically the same steps you followed when you were making your machine? Would the steps always be in the same order? Explain your answers.

Share your answers with your learning facilitator.

Conclusion

In this section you learned to identify the purpose and specifications of your machine, which is important knowledge. You should have gained confidence as you completed the building of your own machine.

As you ended Section 3 you should have realized the importance of clearly stating the function or purpose of the machine you were making; of making a plan that responded to the specifications required; of being flexible and making changes to your design when needed; and of evaluating the success of your machine in solving the original problem.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

Section

4

Did Your Machine Stand the Test?

As you begin to build up your knowledge of machines and how they are put together, it becomes increasingly obvious that you need some form of energy to make a machine work or run.

The word *energy* may also trigger some other thoughts within you. This word is heard and seen many times in the news of today. Think of why this might be so.

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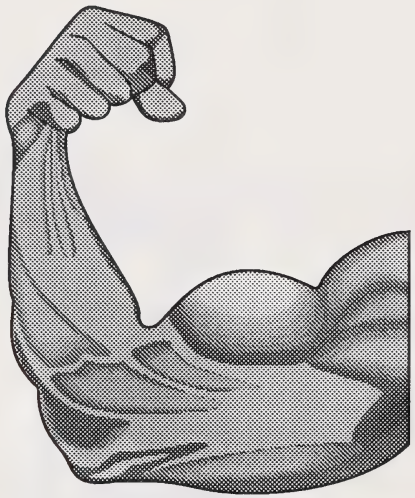
In this section you will learn what sources of energy are used to run machines; how to convert a machine to use different forms of energy; what the role of safety and efficiency is in the design of machines; and what some issues are concerning energy and the environment.

Activity 1: Machines and Energy

When you studied temperature and heat measurement in Grade 7, you found that heat can be generated by many different forms of energy. How many forms of energy could you list?

It has already been mentioned that machines require energy to do work. When you lift something off the ground are you doing work? Your answer is yes, because you are applying some force and moving the object at the same time. Does it then make sense that a human body is a machine?



Scientists, doctors, and other people certainly use the expression *human machine*. You can think of the human body as a machine by making comparisons between your body and another machine, the car.

1. Look at the following chart. Fill in the left column to answer the questions in the right column.

Human Body	Car	Question
	• uses fuels such as gasoline and propane, which are natural non-renewable resources	Where does the energy come from?
	• carries goods, transports passengers, sometimes pulls	What kind of work is done?
	• burns gas to power the motor which uses a transmission (gears) to turn the wheels of the car	How does the machine convert energy?
• produces wastes such as CO_2 and water	• produces waste gases such as carbon monoxide and heat, and it burns oil	What waste products are given off?

Check your answers with your learning facilitator.

The energy you have is obtained from a process called respiration. Sugar in your body cells combines with oxygen to produce a chemical energy. The waste products that result from this reaction are carbon dioxide and water. So you really are an awesome machine!

Activity 2: Making Changes in Design

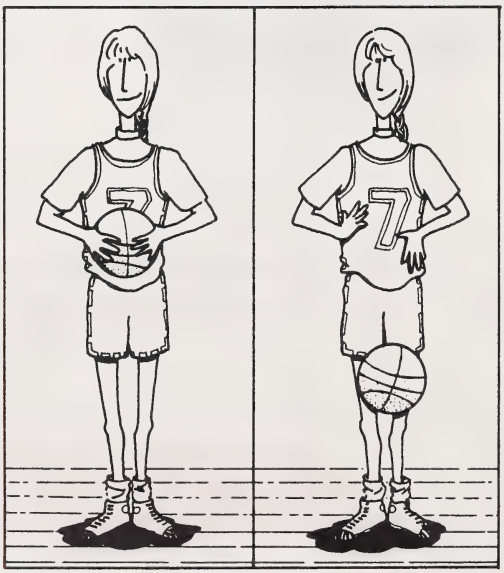
In Activity 1 you explored chemical energy, which is only one type or form of energy. However, you know that machines use many other forms of energy. You should also know that many devices take energy in one form and convert it into other forms of energy. Let us explore these two ideas for a moment. A list of energy types is given. You will need this list to help you answer questions later on.

Forms of Energy

- electrical energy
- light
- sound
- magnetism
- thermal energy
- potential energy
- kinetic energy
- mechanical energy
- chemical energy
- others?

In the list of forms of energy there may be some that you have never heard of before. Read pages 87 to 89 in *Science Directions 8*. In your reading find as many forms of energy as you can.

8 Science Directions



Potential energy: energy that is stored or saved

Kinetic energy: energy of motion

Potential energy is stored energy. **Kinetic energy** is energy of motion. One example of these two forms would be a person holding a basketball. When it is being held, the basketball has stored energy (potential). When the ball is dropped, it is now in motion (kinetic energy). What happens when the basketball actually hits the ground? Is any energy transferred or converted? Well, ask yourself if you hear anything when the basketball hits the floor. Sound, right? What would happen if the basketball hit you in the head instead of the floor? Would you feel anything? What energy is being transferred to you if it hits you or the floor?

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Energy converter: a device that converts energy from one form to another

Some machines, such as the car you discussed in Activity 1, take energy in the form of fuel (chemical energy) and change it into mechanical energy to transport goods and passengers. These machines are called **energy converters**. Can you think of other examples of machines that convert energy?

Think back to the device that you built in Section 3. What was your power source? Would you be able to use a different power source and still do the same job?

A few examples are listed here.

- toaster – converts electrical energy to thermal energy
- flashlight – converts electrical energy to light energy
- steam engine – converts chemical energy to thermal and mechanical energy
- wind-up watch – converts potential energy (in the spring) to mechanical energy (hands of the watch move)

Again, think back to the machine you built in Section 3.

Think of ways in which you could have altered or changed the design of your machine to use other forms of energy.

It is important to our society that we are able to explore ways to operate machines by using other forms of energy that are safe and efficient and do not use up all our natural resources, such as trees, coal, oil, and gas. Many scientists spend a lifetime in careers related to finding new ways to efficiently use energy. We shall discuss efficiency in another section.

The Law of Conservation of Energy states that energy is never created and never destroyed. Scientists say that energy may be transformed or changed from one form to another but it is never lost. It is conserved.

1. Fill in the blanks. (Use the chart or forms of energy list to help you.)

   a. When skiers stand at the top of the hill, they have _____ energy.

   b. A radio uses _____ energy to produce _____ energy.

   c. When a skier rushes down the hill, this is an example of _____ energy.

   d. _____ is a type of energy used to hold items on the side of a refrigerator.

   e. A thunderstorm produces _____ energy, _____ energy, and _____ energy.

   f. A car converts _____ energy into _____ energy.

A toaster converts electrical energy to heat energy. You can describe energy conversion for other devices using similar statements.

2. For each device listed, describe what form of energy is being used and what form of energy is being produced.

   a. radio: _____

   b. stove: _____

   c. bicycle: _____

   d. television: _____

Check your answers by turning to the Appendix, Section 4: Activity 2.

3. In this section you were asked to think back to the machine you built in Section 3. What was the power source you used?

   _____

4. What alternative power sources could you have used? List them.

   _____

   _____

   _____

5. In the space given describe changes you would need to make in the design of your machine to accommodate the different power source?

   _____

   _____

   _____

6. Refer to page 92, Selecting an Energy Source, in your textbook. Look for the different sources of energy that are used to supply various communities. Make a list of the sources.

_____

_____

_____

7. For the machine you designed in Section 3, list some advantages and disadvantages of the different or alternate energy sources you chose.

_____

_____

_____

Check your answers with your learning facilitator.

Activity 3: Looking at Safety

Ask any person who works in an industry that uses machines and energy on a daily basis, and they will tell you they have a healthy respect for the power of machines. Many of you will soon be in the work force. One of the first things you will learn on the job is safety. Most firms have a mandatory safety or orientation course. Why? They want their employees to be familiar and comfortable in their surroundings. More importantly they want their employees to use the proper safety precautions when working with equipment or machines so that they are safe and productive employees.

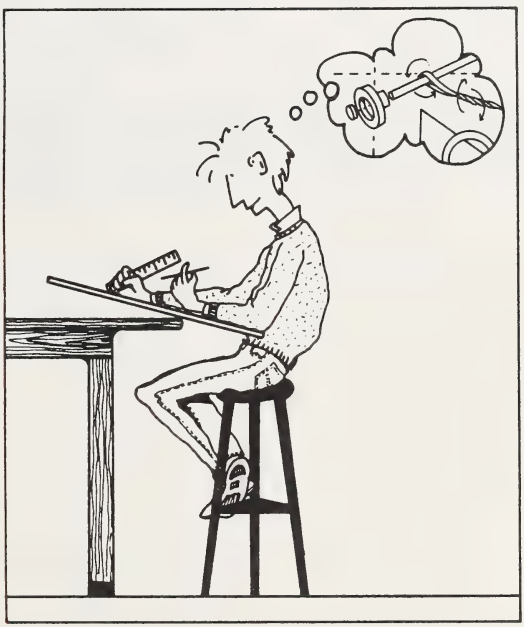
When scientists design and build machines they must take into account the safety and **efficiency** of the machine.

Efficiency: the amount of energy divided by the input energy and multiplied by 100 percent

8 Science Directions

In this activity you will refer to page 91, Activity 2-10, Designing Your Own Self-Propelled Machine. Many science olympics have included this as an event in their competition. Most students enter as a team so that they have the benefit of working and planning together. If you are working on your own you could get help from your facilitator, friend, or relative. You might also get ideas from pictures in magazines or books.

Read the textbook instructions for making your own self-propelled machine, then use the technological problem-solving model to help guide you through the process.



While developing your plan and designing your self-propelled machine, answer the questions that follow.

1. **Understanding the Problem:** What is the problem you are trying to solve? Are there any standards, requirements, or specifications you have to follow?

2. **Developing a Plan:** What is your plan or design? Draw a sketch of your design.

Do not be discouraged if your vehicle does not meet all the requirements or does not even work. This happens. Redesigning a model is a common practice in the field of technology.

3. **Carrying Out the Plan:** Describe what happened as you carried out your plan.

4. **Evaluation:** Did your vehicle meet all the specifications? How could you change the design to improve the ease of operation? Was your machine self-propelled? How far could it travel? How could you change your design to increase the distance travelled?

5. What safety factors did you take into consideration when building your vehicle?

6. Is your vehicle's source of energy (the elastic band) an example of potential energy? kinetic energy? or both?

7. What other sources of energy could you have used to make your vehicle move if you did not have to use an elastic band?

Discuss your answers with your learning facilitator.

Activity 4: Machines and the Environment

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As you know, many people are concerned with our environment. Many outspoken scientists say that our environment and environmental issues will be society's number one priority in the immediate future. How does the environment relate to energy and machines? Two thoughts or ideas should immediately come to mind.

Renewable energy: energy that is in constant supply Solar energy is an example of renewable energy.

Non-renewable energy: energy that becomes depleted Non-renewable energy cannot be replaced after it is used.

- Machines require energy, and this energy, both **renewable** and **non-renewable**, comes from our surroundings (the environment).
- Society and individuals use energy to run machines. This can affect the environment in either positive or negative ways.

Do either Part A or Part B.

Part A involves a tour of a power plant in your area. If you cannot visit a power plant do Part B, which involves research using your textbook and other reference books.

Part A

Visit the power-generating facility of your local power company. Look up the telephone number of the power company. Phone the number and ask for their public relations department. Explain what you are doing and ask for a tour appointment.

To be confident, you should be prepared. Make sure you have your questions ready and in front of you when talking to the tour guide.
Answer the questions that follow Part B.

Part B

Refer to your textbook, page 92, Selecting an Energy Source. Also look up electricity, or production of electricity, in an encyclopedia. Gather as many sources of information as you can on how the electricity in your area is produced (generated) and how it gets to your home. You can obtain information from your local power company; ask for pamphlets to be sent to you or conduct a telephone interview. You will need this information to help you answer the questions that follow.

End of Part B

1. How does the power plant for your area generate the electricity produced? Include in your answer all the energy conversions that take place – be specific.

2. Sketch and label a diagram showing how the electricity is produced and how it actually gets to your home. Refer to the diagram on page 92 of your textbook for help.

3. Refer back to your answer for question 1. Discuss the advantages or disadvantages of using this method of generating electricity.

_____

_____

_____

_____

_____

4. Usually when one form of energy is converted to another form of energy, heat or thermal energy is given off. Can this be a problem? How?

_____

_____

_____

_____

_____

Sometimes power plants or generating stations burn coal, wood, oil, or gas to provide a source of energy. Refer to pages 92 and 93 of your textbook to learn about several problems that could result from using these sources of energy.

5. What special problems are there with the use of fossil fuels?

_____

_____

_____

_____

_____

_____

_____

Check your answers with your learning facilitator.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

1. Fill in the blanks with the correct word.

   a. Machines require _____ to run.

   b. _____ comes in many different forms.

   c. _____ may be converted from one form to another form.

   d. To generate power (electricity) many different sources of _____ are used.

   e. Some of these sources are renewable but many of them are not renewable. Therefore, the efficient use of _____ is important to the environment.

2. List two machines that you use at home.

_____

_____

3. What forms of energy do these two machines use?

_____

_____

_____

_____

4. Can you think of any way that you could use these machines more efficiently so that you do not waste energy?

_____

_____

_____

_____

_____

Discuss your answers with your learning facilitator.

Enrichment

Suppose the machine you made in Section 3 or the vehicle that you made in Section 4 went into production as a toy and was being sold to the public; consider these questions.

1. Discuss the safety factors you would have to consider if you were selling it to children or adults.

2. What changes would you make to your design, either in materials or energy source, so that your machine would be more marketable? In other words, you would sell more of the toys to the public.

3. If you observe and compare many toys, toy cars for example, you will find that they are propelled in many different ways. List several devices that are used to make them move across the floor.

_____

_____

_____

_____

_____

8 Science Directions

Read page 99 of your textbook.

4. What input energy seems to be the most common among the different converters?

_____

_____

5. Which converter is the least efficient?

_____

_____

8 Science Directions

Read page 97 of your textbook.

6. Indicate how efficiency is measured. Show the formula.

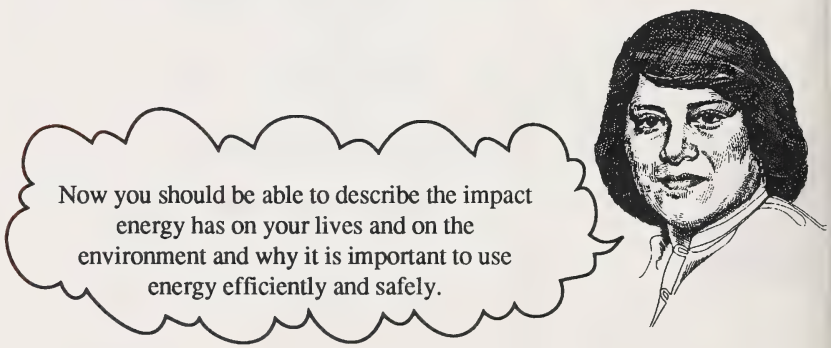
8
Science Directions

7. Suppose electricity costs 8¢ per kW•h and you are using a fridge having the Energuide label, shown on page 99 of your textbook. Calculate the cost of the electricity needed to operate the fridge for one month.

Check your answers with your learning facilitator.

Conclusion

In this section you learned that energy plays an important role in the requirements of machines. Energy may be converted from one form to another, and many scientists around the world are working constantly to improve the efficiency of machines in order to save energy.


Now you should be able to describe the impact energy has on your lives and on the environment and why it is important to use energy efficiently and safely.

Assignment Booklet

ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 4.

MODULE SUMMARY

Machines, and the energy that powers them, play an important role in your lives. You have studied how machines are put together and how the power source may be linked or joined to the machine itself.

The study of the development of the gear and gear systems provides you with a clue to the improvement of machines throughout history.

The fact that some energy sources are depleting will present future scientists with opportunities to use their problem-solving skills to make new machines or improvements to existing machines. These improvements should result in safer, more efficient machines that are more helpful to the environment.

Appendix

Glossary

Alternative
- a choice between two or more things

Complex machine
- a machine made up of several subsystems that perform one or more tasks

Design
- a drawing, plan, or sketch made to serve as a pattern from which to work

Driven gear
- the gear wheel that is having the force applied to it

Driving gear
- the gear wheel that is applying the force

Efficiency
- the amount of output energy divided by the input energy and multiplied by 100 percent

Energy
- the ability to do work

Energy converter
- a device that converts energy from one form to another

Force
- a push or pull acting on an object

Friction
- a resistance to motion on two surfaces that touch

Gear
- a wheel with teeth arranged around its edge used to transfer rotary motion and force from one machine to another

Gear train
- two or more gears which mesh together

Kinetic energy
- energy of motion

Linking
- a joining together

Machine
- any device, simple or complicated, that uses energy to perform a task

Non-renewable energy
- energy that becomes depleted
  Once it is used it cannot be replaced immediately (e.g.wood).

Potential energy
- energy that is stored or saved

Purpose
- the function or use for which a thing is made

Renewable energy	• energy that is in constant supply (e.g., solar)
Simple machine	• a machine usually made up of only one or two parts used to perform a specific task or function
Specification	• a rule or requirement for building and using your machine
Sprocket	• a gear wheel turned by a chain
Subsystem	• several simple machines working together to perform a specific task within a complex machine
Troubleshooting	• making changes to the original design of a machine
Work	• the result of the application of a force through a distance

Suggested Answers

Section 4: Activity 2

1. a. When skiers stand at the top of the hill, they have *potential* energy.
   b. A radio uses *electrical* energy to produce *sound* energy.
   c. When a skier rushes down the hill, this is an example of *kinetic* energy.
   d. *Magnetism* is a type of energy used to hold items on the side of a refrigerator.
   e. A thunderstorm produces *electrical* energy, *sound* energy, and *light* energy. (any order)
   f. A car converts *chemical* energy into *mechanical* energy.

2. a. A radio converts electrical energy to sound energy.
   b. A stove converts electrical, or chemical, energy to thermal, or heat, energy.
   c. A bicycle converts human, or chemical, energy to mechanical energy.
   d. A television converts electrical energy to light and sound energy.

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